



Ground Software

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Staffing



- **Eric Karlin - full time**
 - **GSW Development Environment, Requirements, Space/Ground ICD, CM Plan, C&T design/develop, C&T databases, etc.**
- **Jeff Johnson - full time**
 - **Requirements, FEP design/development, IV&V Contact, System Administration**
- **Jeff Cleveland - when available**
 - **Lead I&T starting in 2002 - after WindSat**
- **Erich Heins - as available**
 - **1553 software on the FEP**
- **Jeff Boyd and Eric Gruner - as available**
 - **TCP socket code and utility coding as available**



Requirements from MRD



- Shall provide Command and Telemetry system for all phases of FAME
- Shall provide command, control, and telemetry system for MOC and SOC
- Shall be compatible with BP ground system architecture
- Shall control the FAME hardware paths (ex. antenna(s)) at BP
- Shall provide control of the ground system configurations via an extendible script language
- Shall support telemetry acquisition and processing of the FAME CCSDS data stream at the FAME data rates
- Shall forward science data packets and instrument SOH packets to the SOC in real-time - **TBR**
- Shall support monitoring of FAME including system status analysis, limit checking, out of limits reporting and trending analysis
- Shall support telemetry archive and playback for both science data and SOH data
- Shall support command uplink and verification
- Shall support three command modes: real-time, ground preplanned and onboard scheduling based on uplinked command loads.
- Shall support verification of command execution, analysis of results, investigation of anomalies, and response to off-nominal situations
- Shall support initiation of safing measures whenever it is determined that a critical event jeopardizes the mission
- Shall support calculation of S/C velocity, range and range rate to 1cm/sec



Design Approach



- **Complete automation - complete control/insight**
- **System shall use a Sun Solaris platform for C&T using NRL's OSComet**
- **Front-End Processor (FEP) shall be a VME chassis running the VxWorks OS**
- **Housekeeping telemetry and commands are passed via 100 Mb Ethernet between the FEP and the C&T nodes**
- **SW interfaces use CCSDS application packet format**
- **All C&T data is archived on the FEP as well as the Sun**
- **Software shall be written in "C"**
- **Scripts shall be written in csh, sh, tcl, or perl**
- **Code re-use is the key to productivity (ICM, WINDSAT, NEMO, BP)**
- **The LAN for formal testing shall be isolated from the NRLnet**
- **Shall support a heterogeneous network of nodes for off-line analysis (PCs and MACs will be able to mount our file system to analyze data offline)**
- **Physical interfaces shall be isolated from the application software via a separate executable or threads (ex. Commanding system and the CEU handler, payloadsim and the i1553 task)**
- **System shall provide APIs to isolate and control**
- **WEB browser shall be supported using ITOS**



GSW Document Summary



Document Title	Document Number	SRR	PDR	CDR
Ground Software Requirements Specification	NCST-SRS-FM001	Draft	Final	
Space to Ground ICD	NCST-ICD-FM003		Draft	Final
FEP Design and Interface Document	TBD	Draft	Final	
GSW Configuration Management Plan	TBD		Final	



Trade Studies

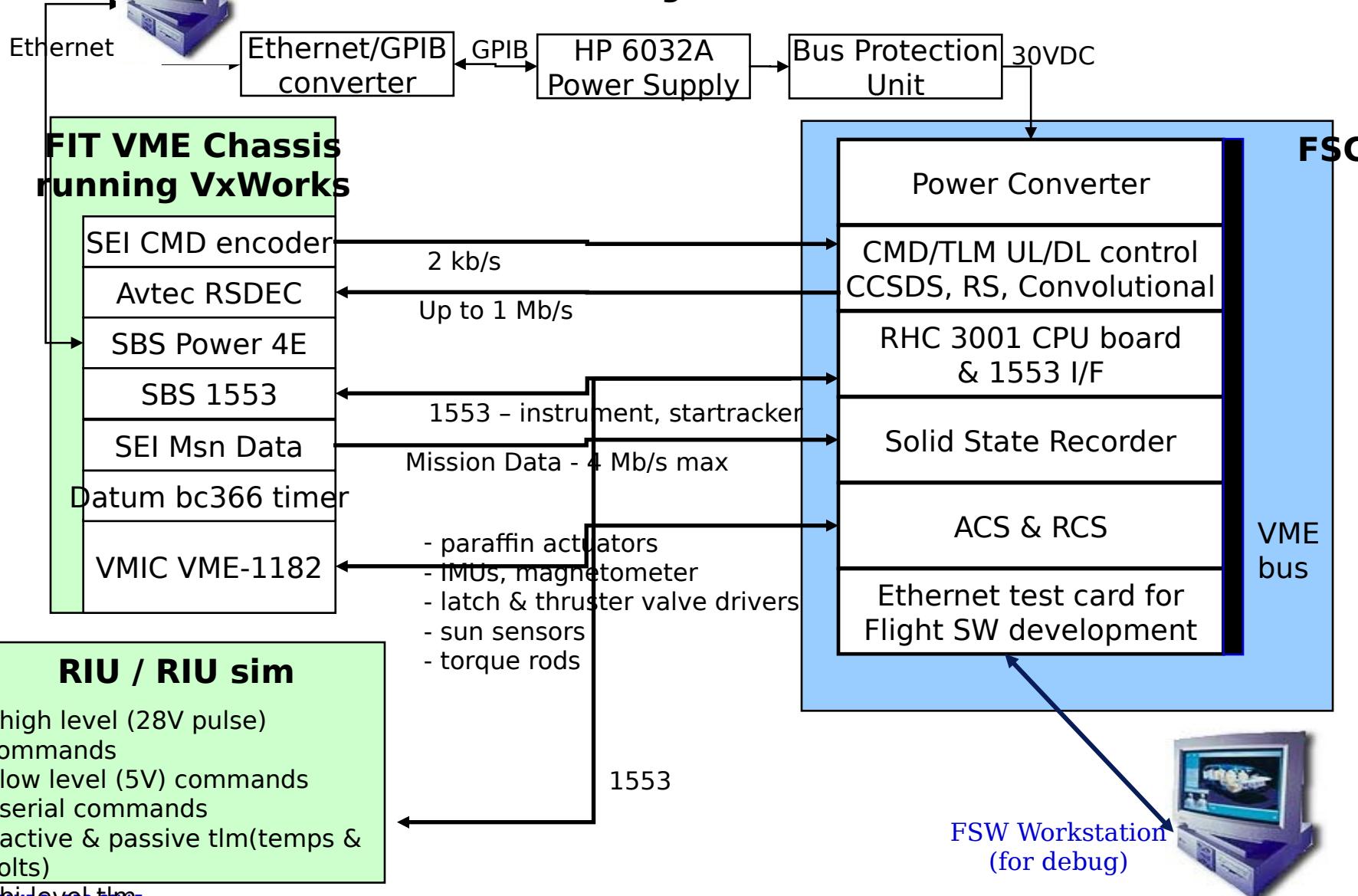


- **Advanced Operations Validation Center (AOVC) Spacecraft Control Software Evaluation - systems evaluated were:**
 - **OSComet 4 (Harris)**
 - **SCL (Interface & Control Systems Inc.)**
 - **ITOS (NASA)**
 - **Epoch 2000 (Integral Systems Inc.)**
- **All the C&T systems could be made to work**
- **System chosen was OSComet 4**
- **After two months of development using OSComet 4, we chose NRL's Comet for FAME (used on WindSat, ICM, NEMO, etc.)**
- **Cost savings are estimated at ~ 200K**
- **Analysis of flight design indicates that we must reuse the ICM ground software (memory load/dump, SCL support etc.) We do not have the staff required to port and test this already verified code.**
- **<http://www.sgss.com/aovc.htm> by Eric Karlin (321-956-8200 x17)**



FSC Testing

In C&T Workstation running Solaris & OSComet



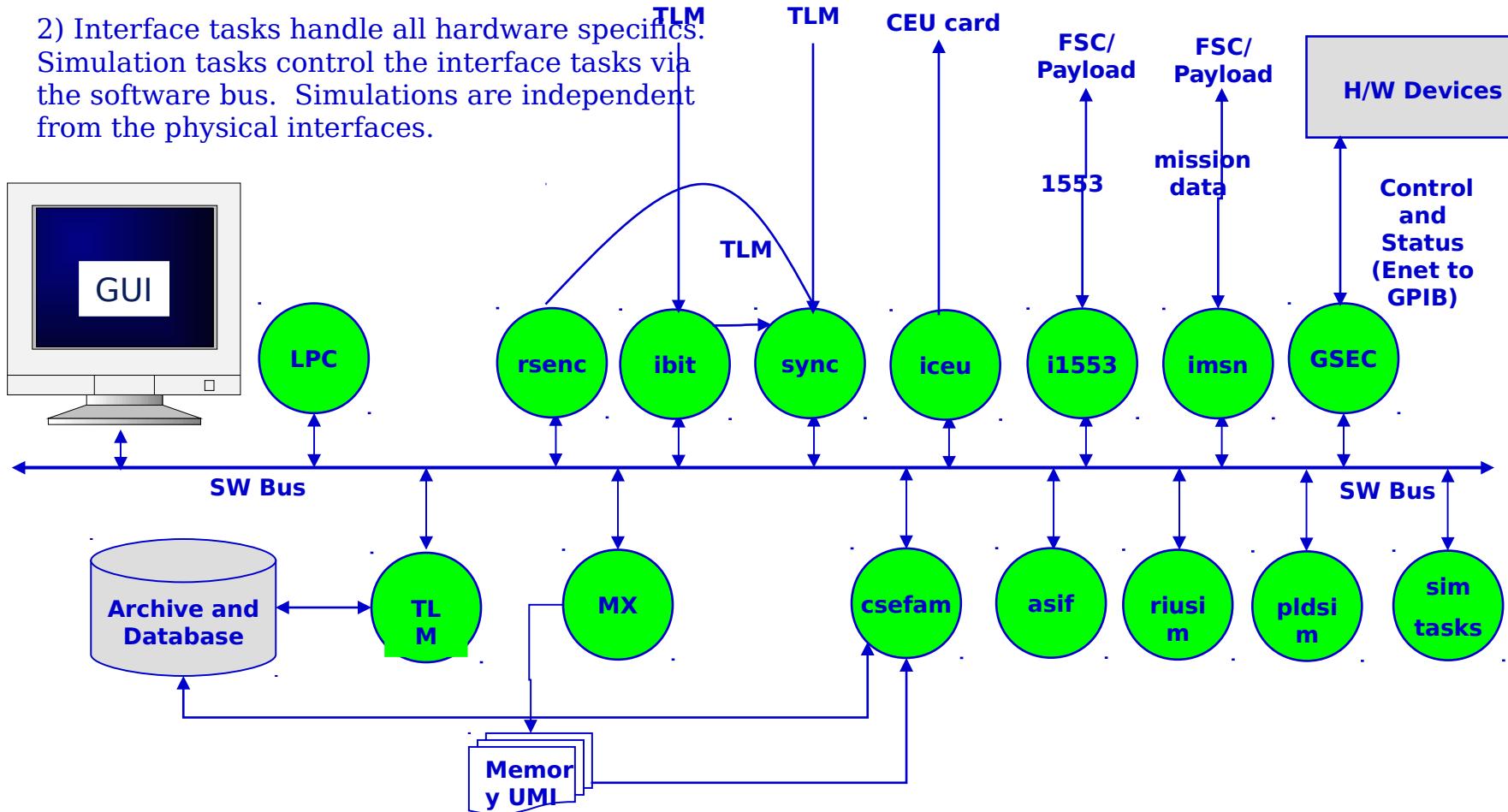


EAGE Ground SW Design



1) The software bus allows us to configure processing components on any node in the LAN. The telemetry and commands may come from/go to any interface (1553, CEU, frame sync, mission data)

2) Interface tasks handle all hardware specifics. Simulation tasks control the interface tasks via the software bus. Simulations are independent from the physical interfaces.





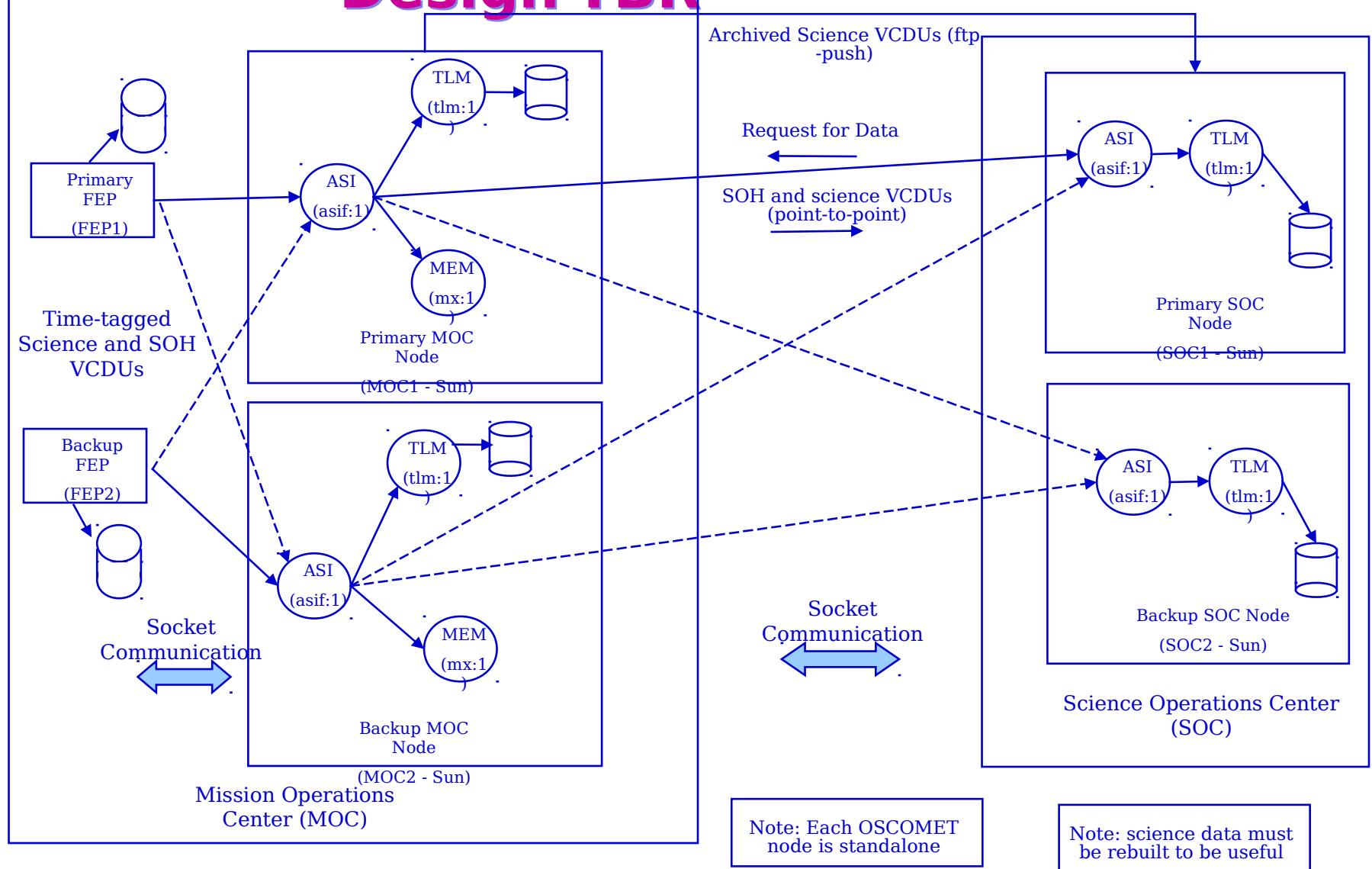
C&T Design Approach



- **Provide a MOC/SOC distributed data system but not a WAN distributed OS/COMET application**
- **Provide redundancy using a simple primary/backup approach.**
- **Work with BP to define control requests and status responses for shared ground station equipment (e.g. exciter, transmitter) - not started.**
- **Reuse design and code fragments from ICM (e.g. tlmasi, tlmprc) and WINDSAT/NEMO (e.g. asiw, cmd, ccstds) as much as possible**
- **Use Oracle DB to store Command and Telemetry (CAT) information**
 - **Data items (symbols), packet formats (decom), commands**
 - **Single point definition with generation of documentation, OS/COMET databases, and C code**
- **Provide web-based near-real time telemetry display of high level status using ITOS**
- **Provide web-based historical display of high level status using Oracle DB and Oracle Portal**

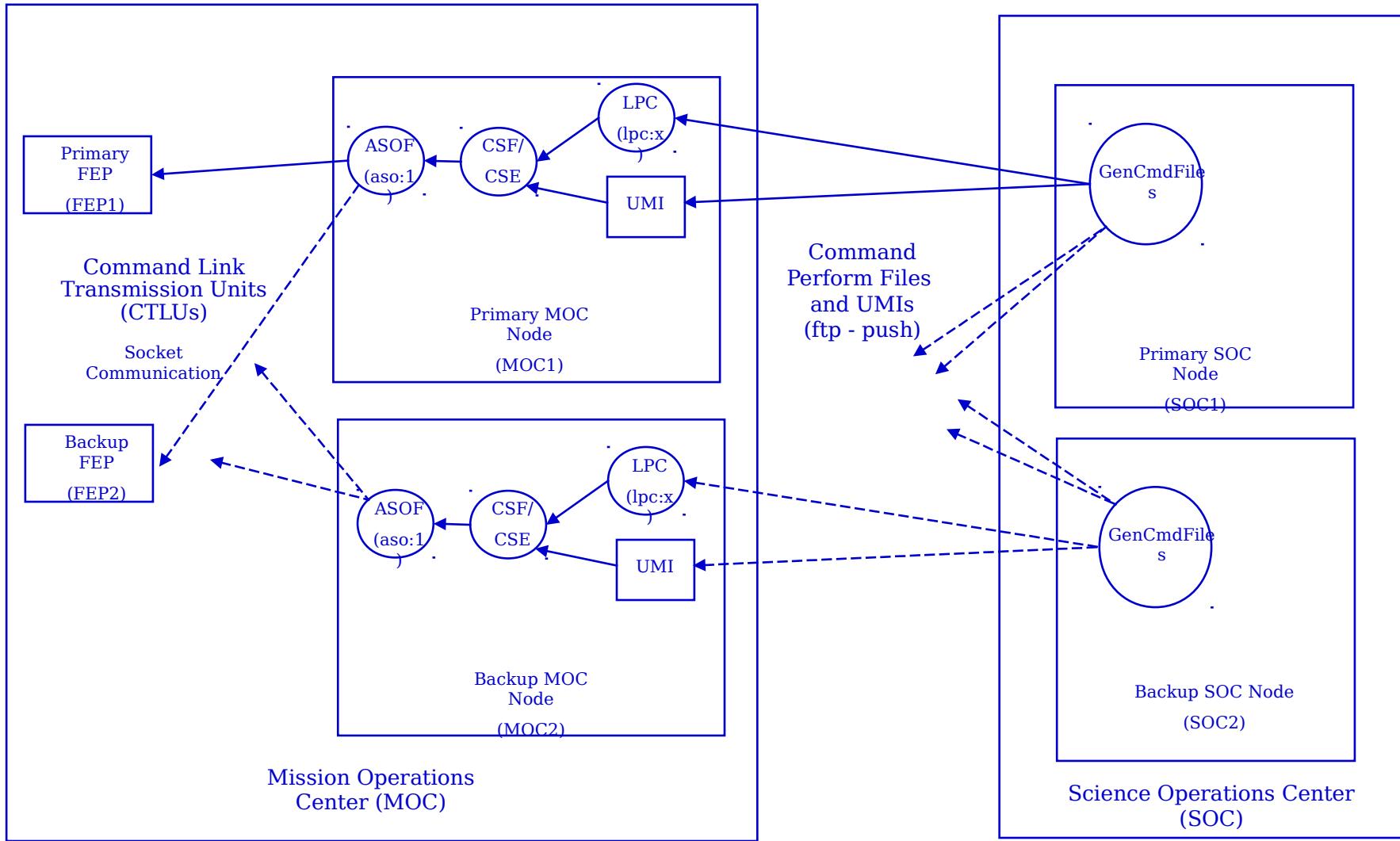


Telemetry Distribution Design-TBR





Commanding Design





C&T Task Status

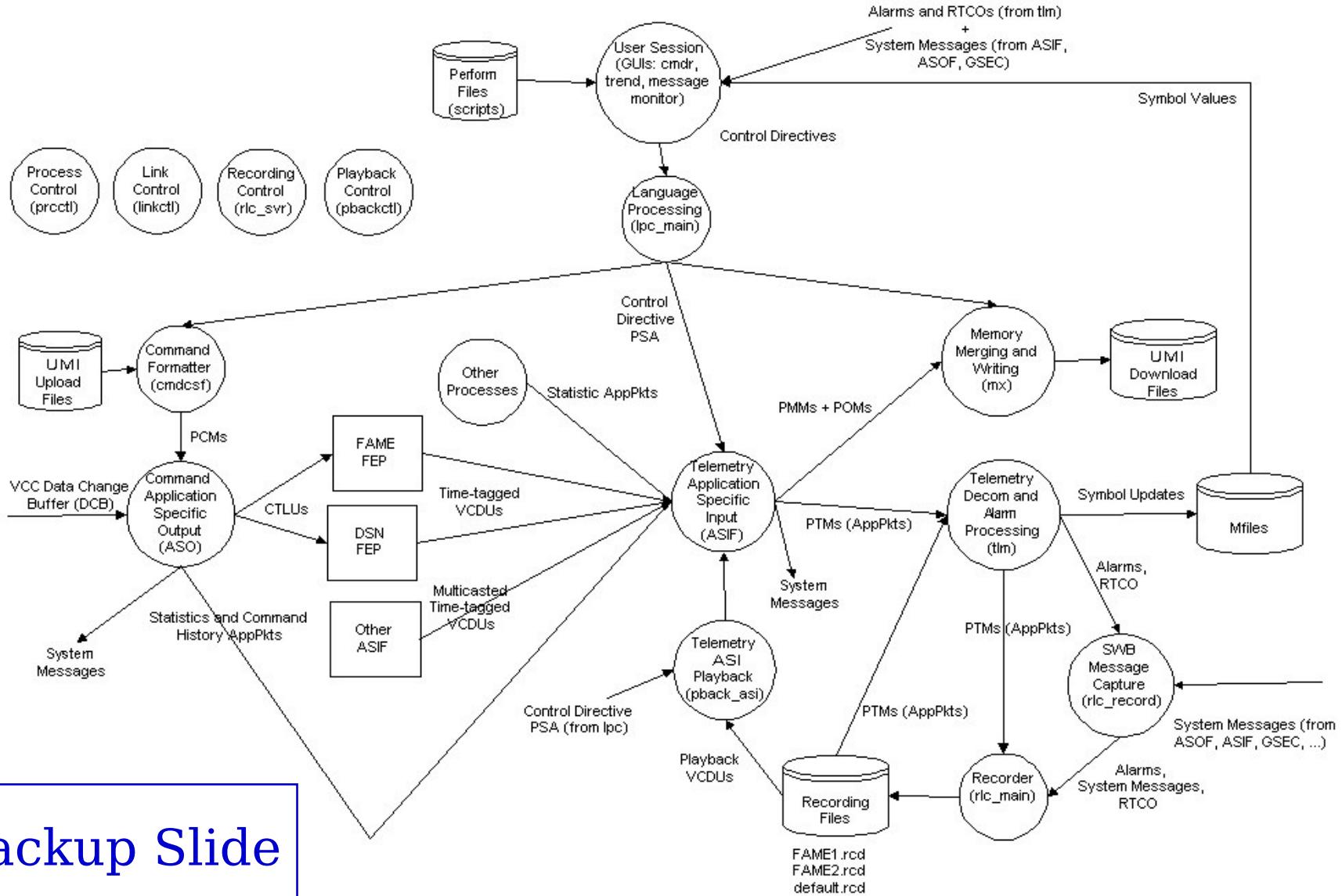


Task/Module	Description	Status	LOC to Date
Includes	C&T shared Include files	50% complete	661
asif	Application specific Input	60% complete	3353
aso	Application specific Output	60% complete	2388
Dbgen	Database tools	80% complete	1746
Util library	Utility code	60% complete	2075
Tools	Test tasks	Complete	955
Total			11178

Backup
Slide



C&T Design Detailed Tasks and Data



Backup Slide



C&T Design Data Interfaces

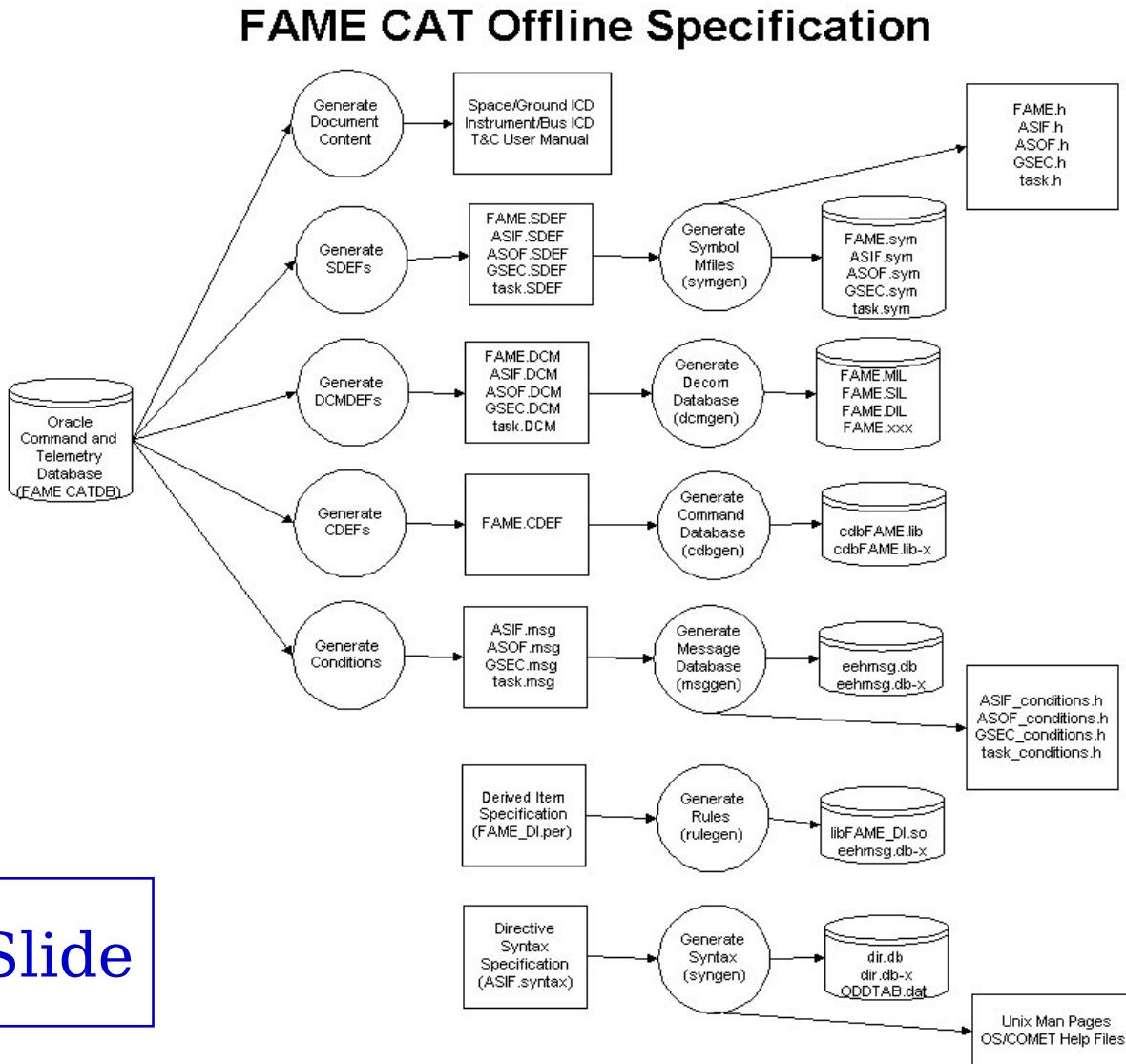


- Between DSN and MOC - TBD
- Between MOC (i.e. BP) and SOC
 - SOC to MOC - science tasking /commanding in OSCOMET perform files
 - SOC to MOC - request for telemetry/science VCDUs
 - MOC to SOC - science VCDUs in OS/COMET recording files - FTP push
 - MOC ASIF to SOC ASIF - multicast time-tagged VCDUs packaged in AppPkts
- Between FAME FEP and NRL C&T/control node at MOC (TBR)
 - Operations and Control (OAC) node to FAME C&T node
 - control perform file execution (setup, shutdown, ranging etc.)
 - FAME C&T node to BP control nodes
 - request to use hardware - (ex. antenna controller, uplink matrix)
- Between FAME FEP and FAME C&T nodes at MOC
 - FEP to ASIF - time-tagged VCDUs packaged in Application Packets (AppPkt)
 - ASOF to FEP - command link transmission units (CLTU)
- Between FAME C&T processes
 - ASIF to TLM - Packaged Telemetry Messages (PTMs)
 - ASIF to MEM - Packaged Memory/Object Messages (PMMs)
 - CSF to ASOF - Packaged Command Messages (PCMs)
 - Misc processes to ASIF - statistics in AppPkts to be decommed

Backup
Slide



C&T Design Processing Specification Tools

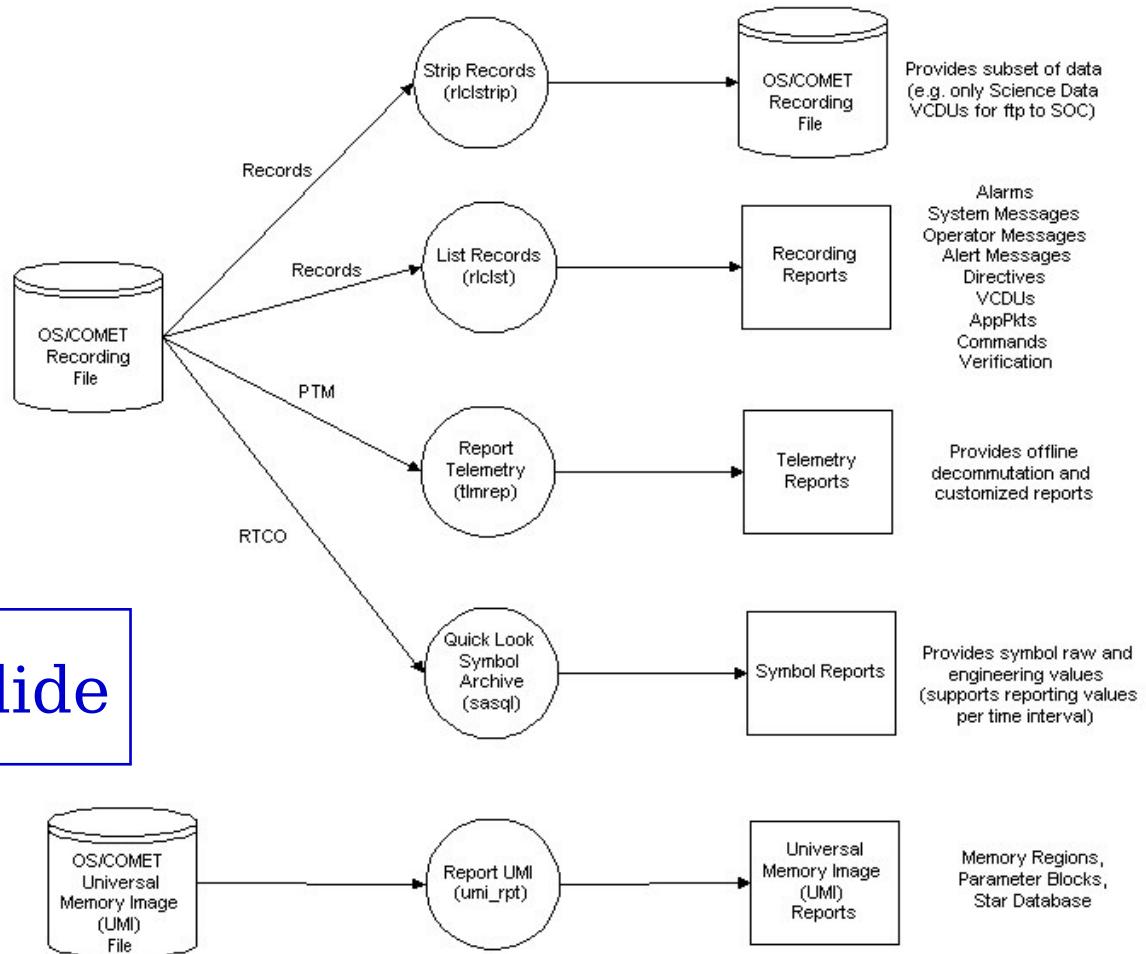


Backup Slide



C&T Design OS/COMET Offline Tools

FAME CAT Offline Processing and Analysis



Backup Slide



FEP Design



- All control from OSComet syntax with defaults for FAME C&T
- FEP will boot from the Sun host
- FEP will log using files on the Sun host (i.e. NFS)
- FEP will provide Browser viewable status via the C&T system
- FEP will support archive within 18 months - format will be OSComet RCD
- Using CCSDS application packets as method of inter-process communication.
- The FEP will not process the packets inside the VCDUs. This will be done by the ASI on the Sun nodes. The FEP will frame sync, derandomize, RS check and time assign.
- Time assignment to be done as follows:
 - Gather "base time" in us from GPS time card before you start collecting frames
 - Init the frame sync card which uses the 33.333MHz PCI clock to count ticks (set count to zero)
 - The card also supports an external clock - we will use this during operations
 - sync card reports it's clock (i.e. counter) with each frame - last bit of frame
- Testing results:
 - the FEP is very fast (1000000 bps takes < 4% CPU)
 - time assignment seems to work - possible Avtec counter problem results in upto 28us error in one frame - followed by correct time in next frame



FEP Time Assignment



Raw “unconverted”
Counts

Frame Sec	Frame nsec	Delta x2-x1	From Expected	t0	t1	t2	t3	t4	FrmCnt
25	740110760			0	5	5C	0D	72	0
25	744206720	4095960	40	0	5	5C	62	C0	1
25	748302679	4095959	41	0	5	59	10	4E	2
25	752398639	4095960	40	0	5	59	CD	79	3
25	756488839	4090200	5800	0	5	52	12	E8	4
25	760590560	4101721	-5721	0	5	52	90	4F	5
25	764686520	4095960	40	0	5	55	3D	7C	6
25	768782479	4095959	41	0	5	55	92	64	7
25	772878439	4095960	40	0	5	5A	70	47	8
26	329927680			0	0A	1F	0D	0	144
26	334023640	4095960	40	0	0A	1F	62	EE	145
26	338119599	4095959	41	0	0A	1E	10	99	146
26	342186760	4067161	28839	0	0A	1E	CE	8	147
26	346311520	4124760	-28760	0	0A	1D	12	EF	148
26	350407480	4095960	40	0	0A	1D	90	9C	149
26	354503439	4095959	41	0	0A	1B	3E	84	150
26	358599279	4095840	160	0	0A	1B	92	E3	151
26	362695240	4095961	39	0	0A	16	70	9B	152
26	366791200	4095960	40	0	0A	16	2E	85	153

Backup
Slide

This is the correct value for frame 148



FEP Task Status

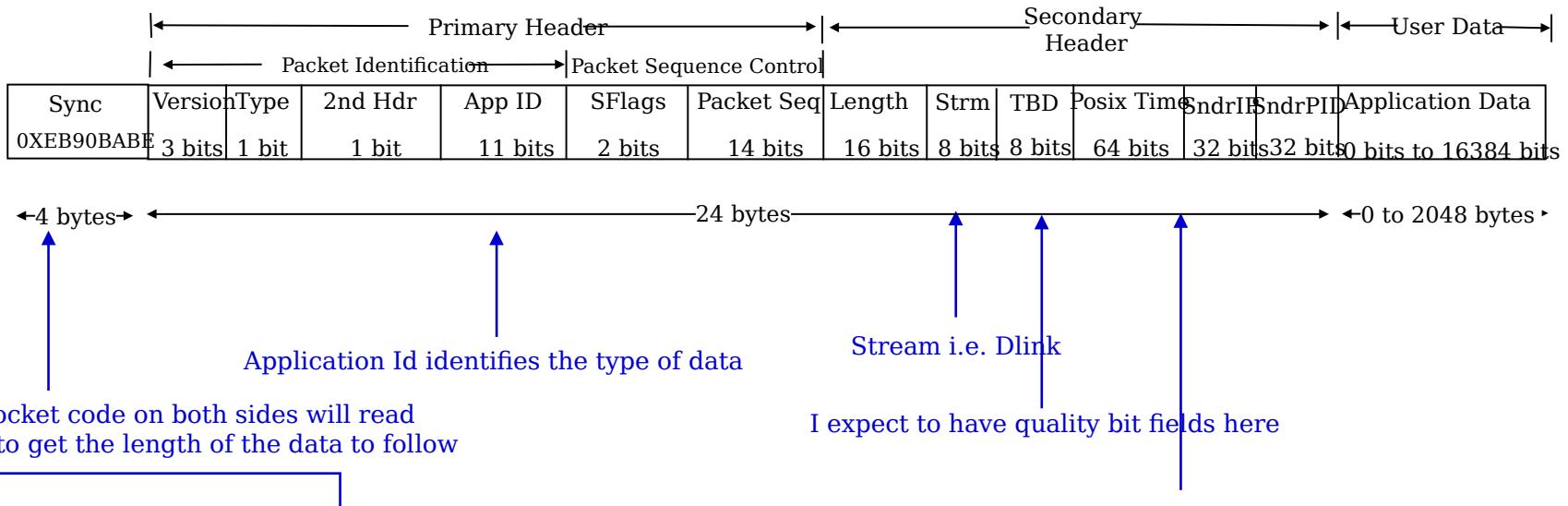


Task/Module	Description	Status	LOC to Date
Includes	FEP shared Include files	80% complete	961
ceu	Cmd Encoder task	90% complete	442
server	Ethernet task	60% complete	340
VME direct	VME direct access task	Complete	205
1553	1553 interface	60% complete	4796
Logging	Logging module	Complete	366
RSENC	RS encoder task	Complete	824
Startup	Startup routine	Complete	105
Status	Status task	Complete	315
RSDEC	RS decoder (frame sync)	95% complete	3271
TimeCode	Time card module	Complete	570
Util	Util code and SWB code	Complete	490
Total			12685

Backup
Slide



FEP Socket/Message Interface



Backup Slide

All inter-task messages on the FEP will use this format (minus the sync pattern)



FEP SWB Status

Commander Session 1: fepstats

FAME9

	Count	Timer	fepstats	10-AUG-01 14:16:23				
	Sent	QID	Messages	Bytes	1Ap	Errors	B/sec	Peak
tEnetRead	016F5CD8		2	178	070	0	0	67
tEnetWrt	0166C440		0	0	000	0	0	0
tVMEacces	015E2BA8		3	236	010	0	0	47
tLooptask	01559310		3	235	010	0	0	47
tTesttime	014CFA78		39	4056	035	0	52	166
tFrameSyn	014461E0	10181	5695033	061		0	0	139160
tRSENCTas	013B6D68	99	11940	051		0	0	2008
tStattask	0132D4D0	158	111223	063		0	1787	1787
tBusWrt	012A3C38	16	1644	051		0	0	328
tCEU	DEADDEAD	4	356	051		0	0	0
Rcvd	QID	Messages	Bytes	1Ap	Errors	B/sec	Peak	
tEnetRead	016F5CD8	0	0	000	0	0	0	0
tEnetWrt	0166C440	10504	5824857	035		0	1839	140999
tVMEacces	015E2BA8	0	0	000	0	0	0	0
tLooptask	01559310	0	0	000	0	0	0	0
tTesttime	014CFA78	0	0	000	0	0	0	0
tFrameSyn	014461E0	0	0	000	0	0	0	0
tRSENCTas	013B6D68	1	44	070	0	0	0	22
tStattask	0132D4D0	0	0	000	0	0	0	0
tBusWrt	012A3C38	0	0	000	0	0	0	0
tCEU	DEADDEAD	0	0	000	0	0	0	0

UNLOCK msgs: 0 Cmds:0000 Boot:0000 Pkt:00 SeqErr:0000 CrcErr:0000

Source: AT:WINDSAT **Mode:** OS/COMET PSA:Closed **Time:** Aug 10 2001 14:16:24
Op Msg: I- FMGR Directive processed successfully.
Perform: ENDFIL fep_setup. 0 [End Of File]
Alert:

Command:

Backup
Slide



FEP Frame Sync Status

Commander Session 1: fepsync

File Display Construct Options Help

FAME9	fesync:	10-AUG-01 14:15:57
Setup: 14:15:04.902	SyncH: 1ACFFC1D	SyncL: 00000000
Active: YES	MaskH: FFFFFFFF	MaskL: 00000000
RSTAT0: 0320 RSTAT1: 6620	FrameLen: 512	
StatCnt: 41	Slip_Window: 0	
FrameCnt: 5116	Sync_Errors: 0	
Overrun: 0	Check_Frames: 0	
Dropout: 0	Flywheel_Frames: 0	
Winend: 5116	Input_Code: NRZL	
Lock_Intrpts: 0	Word_Order: FORWARD	
CRCErr: 0	Bit_Order: MSB	
FramesPerSec: 244	Data_Invert: NO	
BitsPerSec: 999424	Polarity_Correct: YES	
FrameSyncQA: 1	Clock_Invert: NO	
SyncErrsQA: 0	RS_Enable: YES	
CrcErrsQA: 0	RS_Offset: 4	
DropOutQA: 0	RS_InterleaveDept: 2	
BitSlipsQA: 0	CRC_Enable: NO CRC_Mode: NO	
TimeStampQA: 00000000 163B7117	Randomize_Enable: YES	
FrameSyncQAFlags: 0000000F	Quality_Annotation: ADD	
SICC APC CLK RSEC_IRQ R_I IEF IHF IFF IOVRN OEF OHF OFF IOVRN		
LOCK NO YES NO NO EMPTY NOT NOT OK EMPTY NOT NOT OK		
Ver Ty 2nd AppID sFlgs seqCnt pktLen stm secs nsecs sendIP sendPID		
0 TLM 1 063 03 0029 137 97 39916795 27AD5023 84FAACAA 013B6B50		
UNLOCK msgs: 0 Cmds:0000 Boot:0000 Pkt:00 SeqErr:0000 CrcErr:0000		

Source: AT:WINDSAT Mode: OS/COMET PSA:Closed Time: Aug 10 2001 14:15:58
Op Msg: I- FMGR Directive processed successfully.
Perform: ENDFIL fep_setup. 0 [End Of File]
Alert:

Command: I Interrupt

Backup
Slide



FEP Raw Telemetry Frame



Commander Session 1: feptlmraw

File Display Construct Options Help

FAME9 feptlmraw 10-AUG-01 14:17:16

Sync:	1ACFFC1D	Raw frame data	Res:	86 E5
62 81 00 04 AB 00 00 07 08 09 0A 0B 0C 0D 0E 0F	000-00F	Time:	00 7A 68 A5 A1	
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F	010-01F	flags:	80	
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F	020-02F	bitSlips:	00	
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F	030-03F	crcErr:	OK	
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F	040-04F	apcFlag:	NONE	
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F	050-05F	lockFlag:	NOT	
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F	060-06F	unlockFlag:	OK	
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F	070-07F	flyFlag:	LOCK	
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F	080-08F			
90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F	090-09F			
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF	0A0-0AF	FrmCnt:	11205	
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF	0B0-0BF	Route:	00	
C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE CF	0C0-0CF	Terse_Qual:	00	
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE DF	0D0-0DF	Errs:	0000	
E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE EF	0E0-0EF	Fixed_Cw_Cnt:	00	
F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE FF	0F0-0FF	Nofix_Cw_Cnt:	00	
00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F	100-10F	Error_Bitmap:	0000	
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F	110-11F	Nofix_Bitmap:	0000	
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F	120-12F	Frame:	00:02:03.940	
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F	130-13F			
Ver Ty 2nd AppID sFlgs seqCnt pktLen stm secs nsecs		sendIP	sendPID	
0 TLM 1 061 03 2BC7 562 97 39916769 000D5DDC 84FAACAA 014CF860.				
UNLOCK msgs:	0	Cmds:0000 Boot:0000 Pkt:00 SeqErr:0000 CrcErr:0000		

Source: AT:WINDSAT Mode: OS/COMET PSA:Closed Time: Aug 10 2001 14:17:15
 Op Msg: I- FMGR Directive processed successfully.
 Perform: ENDFIL fep_setup. 0 [End Of File]
 Alert:

Command: I Interrupt

Backup Slide



Risks/Issues



- **Lack of a dedicated System admin, CM, DB person**
- **Simulation fidelity - ex. RIU and payload simulations**
- **Closed loop (i.e. attitude) simulations - staff?**
 - **Attitude simulation will run on the FEP - design issues**
- **Will Jeff Cleveland be available to lead testing in 2002?**
- **VME cards are not coming on schedule**
- **Payload test support with Lockheed - duration and level of effort**
- **Cost of additional hardware ((2) receiver (2) bitsync/viterbi decoders, (2) exciters, freq. generators etc.) These are not in the Ground SW or EAGE budgets.**
- **How will the bit rate changes work?**



FSC Test Bed Needed Hardware



- **SEI Mission Data card**
- **Valve sim card**
- **ACS sensor sim card**
- **Bit Sync/Viterbi Decoder - not needed initially - TTL or 422 output to the frame sync**
- **BPU - the BPUs from NEMO (bld 35) are being used by WindSat**
- **Pass-1000 1553 analyzer**
- **UPS power for the racks**
- **Various cables**
- **BOBs**



Top Level Schedule



• FAME PDR	Oct 2001
• EAGE Design Review	Sep 2001
• Initial FEP Complete	Sep 2001
• FEP supports FSC box testing	Sep 2001
• Space/Ground ICD available	Oct 2001
• EAGE system demonstration (ATP)	Dec 2001
• FAME CDR	Jun 2002
• EAGE System available for test	Apr 2002



IV&V Status



- **BP will provide IV&V**
 - **BP is providing the support**
 - **This will facilitate the transition from I&T to EE&C and operations**
- **Approach**
 - **BP and FAME I&T will create a MOA. BP will provide (TBR):**
 - **Review the design and all documentation**
 - **Review the design and code**
 - **Create reports for Mark Johnson prior to system milestones (PDR, CDR, TRR etc.)**
 - **BP will provide up to 6 weeks of support through FAME CDR**
- **Scope**
 - **BP IV&V will only provide coverage for Ground Software Efforts**